# Water limitation of enery crop rotations – A simulation study for German conditions

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Introduction and Hypotheses	Materials a	
General Background	M	
European and German policy has focused on promoting renewable energy use	Module for Eva	
⇒increased cultivation of biomass crops for use in biogas plants	✤ Module for soi	
Biomass production (for biogas plants) is mainly based on maize monoculture	Modules for plan	
⇒ environmental problems (e.g. NO <sub>3</sub> -leaching and decrease of soil carbon stocks and soil humus)	wheat (based or (de	
Global Hypothesis	Penman-	
Energy crop rotations or grassland are under certain regional conditions an alternative to maize monoculture	LA cro high	
- Supporting assumptions and resulting hypotheses-		
<ul> <li>✤ Maritime sites (northern parts of Germany):</li> <li>Relatively low average temperatures per year (~8.5 °C)</li> <li>⇒ suboptimal region for cultivating maize - alternatives?</li> </ul>	Implemented in (HU	
High annual rainfall of 750-800 mm (evenly dristributed) ⇒energy crop rotations with high water requirement possible (winter intercroping)	Simulation per	
Large areas of permanent grassland (high groundwater level)	2 climates (site maritime (77)	
Continental sites (eastern and central parts of Germany):	✤ <u>1 soil typ:</u>	
Higher temperatures during vegetation period ⇒ favours maize cultivation Lower annual rainfall ⇒ maize with a high water use efficiency (C <sub>4</sub> -plant)	* 3 crop rotation     maize monocula     beat for silage     Galculation     con	

### Literatur:

1) Herrmann, A., A. Kornher, and F. Taube 2005. A new harvest time prognosis tool for forage maize production in Germany. Agric. For. Meteorol. 130, 95-111. 2) Kage, H., and H. Stützel. 1999. HUME: An objekt oriented component library for generic modular modelling of dynamic systems. In "Modelling cropping systems". (C. S. M. Donatelli, F. Villalobos, J. M. Villar, ed.), pp. 299-300, Lleida 1999. European Society of Agronomy.

# and Methods

# odular Model Approach

### potranspiration:

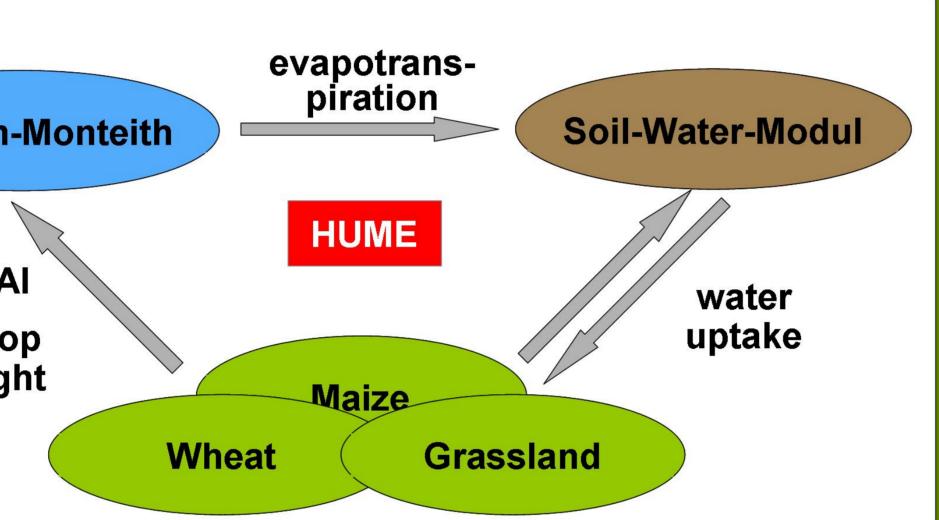
ased on Penman-Monteith

### -water balance:

ootential based layer model

### nt growth and quality:

CERES Wheat), grassland and forage maize ed from the model FOPROQ<sup>1</sup>)



object orientated modelling environment E<sup>2</sup>), crop objects as linked list

# Simulation study

36 years (1970 – 2006)

n, 8.7 °C), continental (508 mm, 9.2 °C)

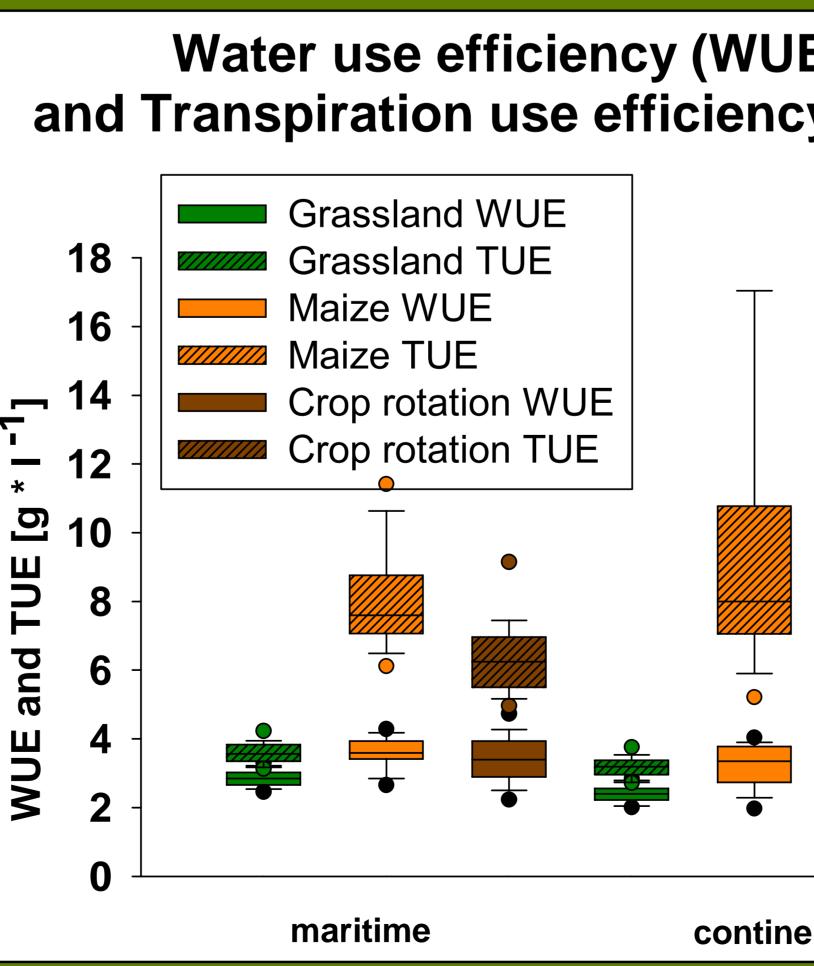
visol (23 % field capicity)

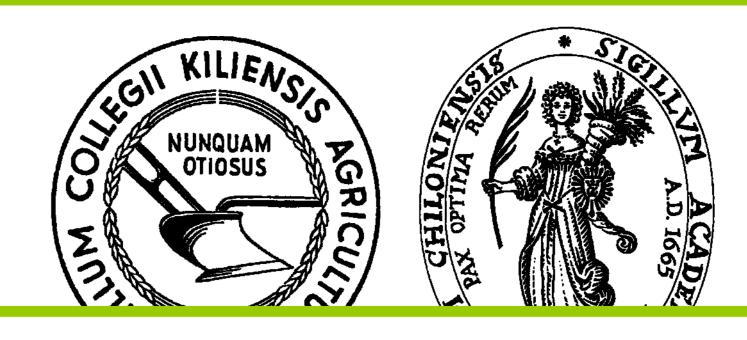
e, grassland (4 cuts), energy crop rotation se, overwintering rye grass (2-3 cuts), maize)

n of dry matter production with particular sideration of water use efficiency

DM [t/ha] (CV [%]) Grassland Maize	maritime 12.7			oductivity	Maritima	
(CV [%]) Grassland	12.7	con			Maritime s	
			tinental	Dry matter (DM)	Concerning the dry matter productivity this	
Maize	(6.9)		9.6 (15.5)	<ul> <li>maize ≈ crop rotation &gt; grassland</li> <li>maritime &gt; continental</li> </ul>	rotations can be an alternative to m higher transpiration use effiency and grov	
	15.8 (15.0)		12.1 (24.3)	Coefficient of variation of dry matter (CV)	longer growth period and a total higher t	
<b>Crop rotation</b>	15.7 (22.9)		12.2 (23.3)	<ul> <li>crop rotation ≥ maize &gt; grassland</li> <li>continental &gt; maritime</li> </ul>	Continenta	
		Wat	er bal	Dry matter productivity of maize monoculture		
[mm/a]	T	E	D	Transpiration (T)	preliminary simulation result: possible unde the crop rotation due to underestimation of (winter intercred)	
Grassland, maritime Maize,	318	129	279	<ul> <li>grassland &gt; crop rotation &gt; maize</li> <li>maritime &gt; continental</li> </ul>	⇒ The simulation model has to be	
maritime Crop rotation,	201	239	300	Evaporation (E)	experimenta 다	
maritime Grassland,	248 291	205 109	280 70	<ul> <li>maize &gt; crop rotation &gt; grassland</li> <li>maritime ≥ continental</li> </ul>	Field experiment	
continental Maize, continental	141	234	111	Drainage (D) • maize > crop rotation ≥ grassland	Cooperative project (BIOGAS-EXPER (location, crop rotation, nitrogen-amount	
Crop rotation, continental	199	191	84	<ul> <li>maize &gt; crop rotation ≥ grassiand</li> <li>maritime &gt; continental</li> </ul>	2006-2009	
	Ŵ	later i	use ef	ficiency	Project over Process Optimization	
and Transpir	use efficie	ency (V e efficie	NUE)		Methane Yield per Crop Unit   (Agricultural Engineering)   Yield Formation & Sefficiency Energy Crops (Agronomy and Crop Science) N-Dynamics in N-Dynamics in Kitrate Load and Concentration	

Results a	nd Dis	cussion	Conclusions and Outlook Maritime s			
	Dry	matter p				
DM [t/ha] (CV [%])	maritime	continenta	<b>Dry matter (DM)</b> • maize $\approx$ crop rotation > grassland	Concerning the dry matter productivity this		
Grassland	12.7 (6.9)	9.6 (15.5)	maritime > continental     Coefficient of variation of dry	rotations can be an alternative to m higher transpiration use effiency and grov		
Maize	15.8 (15.0)	12.1 (24.3)	• crop rotation ≥ maize > grassland	longer growth period and a total higher t		
Crop rotation	15.7 (22.9)	12.2 (23.3)	<ul> <li>crop rotation 2 maize &gt; grassiand</li> <li>continental &gt; maritime</li> </ul>	Continenta		
		Water b	alance	Dry matter productivity of maize monoculture preliminary simulation result: possible under		
[mm/a]	T	E D	Transpiration (T)	the crop rotation due to underestimation of (winter intercro		
Grassland, maritime Maize,	318	129 279	<ul> <li>grassland &gt; crop rotation &gt; maize</li> <li>maritime &gt; continental</li> </ul>	⇒ The simulation model has to be		
maritime Crop rotation,	201 248	239 300 205 280	Evaporation (E)	experimenta <sup></sup>		
maritime Grassland, continental	291	109 70	<ul> <li>maize &gt; crop rotation &gt; grassland</li> <li>maritime ≥ continental</li> </ul>	Field experiment		
Maize, continental	141	234 111	<ul> <li>Drainage (D)</li> <li>maize &gt; crop rotation ≥ grassland</li> </ul>	Cooperative project (BIOGAS-EXPER (location, crop rotation, nitrogen-amount		
Crop rotation, continental	199	191 84	<ul> <li>maritime &gt; continental</li> </ul>	2006-2009 Project over		
	W	ater use	efficiency	Process Optimization Quality Parameters of Fermentation Residue		
and Transpi 18 16 16 14 12 5 10 10 10 10 10 10 10 10 10 10		UE	<ul> <li>Water use efficiency (WUE)</li> <li>maize ≥ crop rotation ≥ grassland</li> <li>maritime ≈ continental</li> <li>Transpiration use efficiency (TUE)</li> <li>maize &gt; crop rotation &gt; grassland</li> <li>maritime ≈ continental</li> </ul>	Actional Figure Corp Unit (Agricultural Engineering) Agricultural Engineering Stried Formation & N-Efficiency Energy Crops (Agronomy and Crop Science) Agronomy and Crop Science Antional Agricultural Engineering Agricultural Engineering		





## sites

- is simulation study shows that crop naize monoculture. 🗸 🗸 🗸
- th rates of maize is balanced by a anspiration of the crop rotation

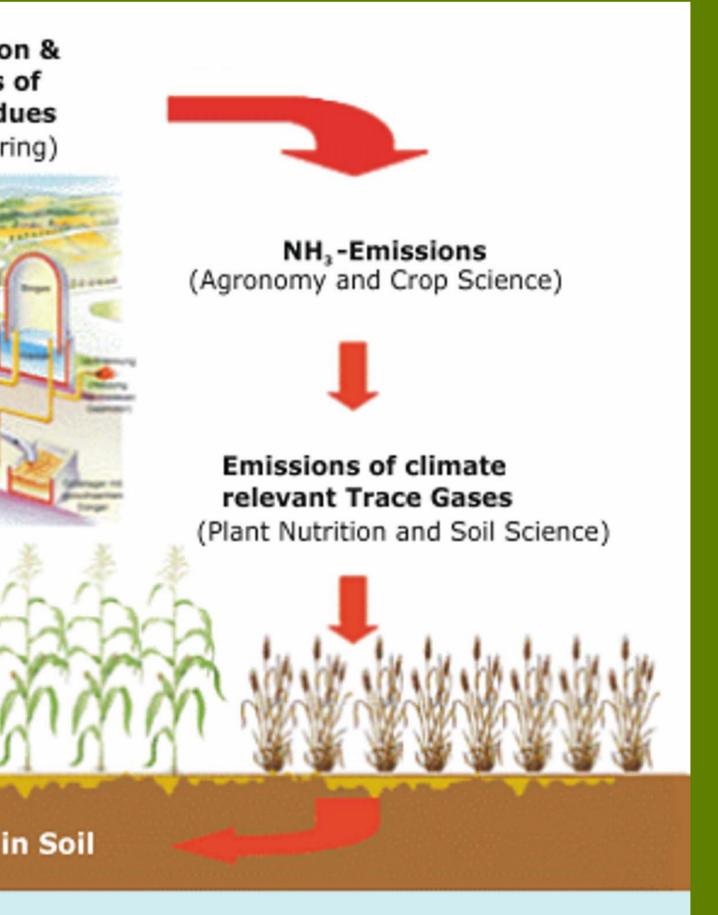
# al sites

- re and crop rotation also similar 구
- nation of soil water demand in ry matter productivity of rye grass
- e calibrated and evaluated by al data.

# t in progress

ERT) including a multi-factorial t, nitrogen-form) field experiment

### erview



tions in Leachate

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